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BIOGEOGRAPHY AND INVASION BIOLOGY- A THEORETICAL STUDY

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ABSTRACT

Biogeography is a 19th-century discipline of geography that analyses the spatial distribution of creatures such as plants and animals. Biogeography is the scientific study, description, and documentation of the distribution and spread of species around the globe, as well as their environmental variables. Since, Invasion Invading species biology is one of the more recently created fields of biology that deals with the problem of invasive species. The phrase "invasive species" refers to plant and animal species that have been brought to new geographies and ecosystems and compete fiercely with native species that are infringing on their ecological area. They acquire and use space, soil, sunlight, nourishment, and other natural resources disproportionately, depriving native species of all available resources. They reproduce quickly and consistently, replacing native creatures. There has been transportation of species, consciously or unknowingly, since the geographical voyages, mainly during the 17th and 19th centuries. Many animals and birds migrate as a natural part of their life cycle, driven by physiological needs and environmental changes. This natural migration is not a factor in species introduction, which is mostly due to human activity.

One of the major causes of biodiversity loss is biological invasions. As biological invasion threats grow, identifying high-vulnerability locations is becoming increasingly important. Biological invasions continue to have a significant negative influence on the environment and the economy. It's vital to understand why some introduced species become invasive before they can be managed. The ecology and physiology of the species in the invaded range have been studied in order to determine the processes underlying invasion success. However, a rising corpus of research highlighting insights derived from investigating invasion success as a biogeographic issue is highlighting the use of biogeographic techniques. Invaders have the ability to drastically alter the species composition and function of native ecosystems through competition, predation, and habitat disruption. Biological invasions have a significant economic impact on the world economy, with annual costs in the United States alone estimated at over $100 billion. Invasions occur when organisms are introduced outside of their native or historic range, either purposefully or unintentionally, and then spread effectively in their new surroundings. Exotic species, which include cattle, crops, and garden plants, are any species that isn't native to a specific location. Biological invaders are non-native creatures that spread outside of an ecosystem dominated by humans. The distinguishing characteristics of invasions, such as some marine species, plant species, and animals, are some remarkable instances. In addition, we document the biogeographic distribution of invasive species, as well as the diversity of species, habitats, and climate zones studied. A fact study and prediction analysis of key records and data related to our research aim were included in our research, which let us come to a decision on the obstacles, potential difficulties and future prospects of "Biogeography and Invasion Biology- A Theoretical Study."

KEYWORDS: Biogeography, Invasion Biology, Exotic, Global Impact, Species Diversity

1. HYPOTHESIS:

This theoretical investigation of Biogeography and Invasion Biology— A theoretical study is conducted to define the locations where alien species are found, as well as how we confront biodiversity loss owing to biological invasion due to climate, habitat, and other factors. The article looks at the future potential and challenges to our ecosystem (globally).

2. INTRODUCTION:

2.1. Biogeophraphy:

As we all know, "British naturalist Alfred Russel Wallace" is credited with pioneering the study of biogeography as a discipline. "Alexander Humboldt, Aime Bonpland, Captain James Cook, Joseph Banks, Charles Darwin, Alexander Russell Wallace, Joseph Dalton Hooker, Thomas Huxley, and other naturalists" contributed to the development of the subject.

Wallace was an intrepid explorer. He travelled extensively across the Amazonian woods of South America, as well as the forests of Indonesian and Malaysian islands, between 1848 and 1866. He amassed almost 10,000 specimens, catalogued them, and dispatched them to London. His quest for natural scientific knowledge was extraordinary, and he eventually created the discipline of biogeography. In 1876, he released a large book called "The Geographical Distribution of Animals." Along with Charles Darwin, he was a co-discoverer of the theory of evolution by natural selection. Between 1831 and 1836, Darwin completed a circumnavigation expedition that took him across South America, the Indian Ocean, and the Pacific Ocean islands (Alfred Russel Wallace; 2014).

The explorations of German geographer Alexander Humboldt, French botanist Aime Bonpland, and British naturalist Joseph Banks, among others, sowed the roots of biogeography's understanding. Darwin and Wallace built it on top of a solid

theoretical foundation. Both naturalists travelled to different parts of the world, investigating diverse geographies, and came to the same evolutionary concepts based on Natural Selection by chance. Wallace's idea was based on observations in Indonesian and Malaysian rain forests, while Darwin's theory was based on observations in South American woods and the Galapagos Islands. The observational and analytical data underlying species geographic distributions, as well as the theoretical underpinnings underlying those distributions, were a stepping stone in the development of evolutionary theory (Alfred Russel Wallace; 2014 and Iain McCalman; 2009).

Since the discovery of maritime routes and the development of means of sea travel in the 15th century, people have introduced species into numerous parts of the planet, either willingly or unwittingly, where they had never been encountered before. Ecological imbalance has resulted as a result of these imports, and the consequences have been felt profoundly in some regions. The elimination of flightless birds known as dodos on the Mauritius islands is a typical example. The Portuguese colonised the Indian Ocean islands of Mauritius in the 16th century, and the inhabitants, along with their tamed cats and dogs, drove the dodo population to extinction. Similarly, the introduction of brown snakes to Guam, a Pacific Island, has destroyed the local bird population (Andrea Wulf; 2014).

The species on islands have developed in isolation and have specific behavioural features. When a foreign species is brought into their island habitats, these characteristics become detrimental. In the absence of predators and when physiological and ecological flight requirements do not exist, many birds in such areas have lost their capacity to fly as an evolutionary mechanism. In their fundamental work "The Theory of Island Biogeography," published in 1967, American biologists Edward Osborne Wilson and Robert Mac Arthur described the dynamics of island biogeography (Barry Cox et al., 1976)

Many species of plants and animals have been removed from the wild and cultivated by human means outside of their natural occurrence since the birth of civilization, when people began domesticating plants and animals. This was the first-time humans messed with organisms' geography. Many of these plants and animals have lost contact with their wild ancestors, as well as their wild characteristics. With global cultivation, the concept of endemism in flowers and vegetables is blurring. These introductions were vital for human survival, as humans' means and modes of eating have evolved since their cave days.

Indian Perspective

Many plants and invasive animals have spread around the world, along with food crops. Many local environments have been ravaged by weeds such as lantana, parthenium, and eupatorium. The lantana plant, which was first introduced to India as an attractive plant in the nineteenth century, has now spread throughout the country, including woods, rural areas, and urban areas. With its tenacity and propagation, this plant has quickly spread to many parts of the globe and is a fierce competitor to native species. During the green revolution, parthenium was introduced to India. Its pollen causes respiratory distress and has become a threat to natural flora. Similarly, the emerald ash borer has wreaked havoc on America's and Europe's woody fauna, while cane toads have wreaked havoc on native wildlife in the United States (IUCN and NOAA).

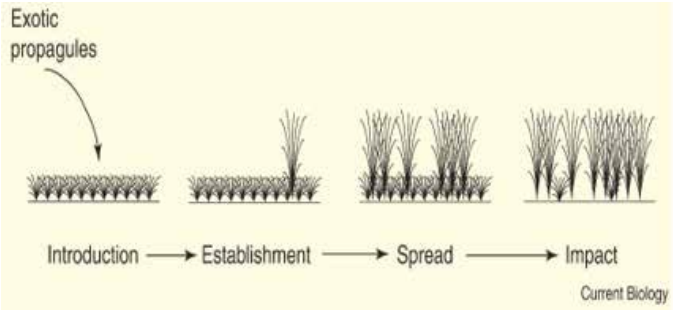
Peacocks, which were initially introduced from India, have become an invasive species in metropolitan areas across the United Kingdom. Indian Myna has become invasive in many places, wreaking havoc on indigenous bird populations. Burmese Pythons have spread to every nook and cranny of the Florida Everglades marshes, becoming a familiar sight even in metropolitan areas. Introduction goats have degraded the fragile environment of the Galapagos Islands. Because of their ravenous hunger and capacity to grow quickly, African cat fish have seriously harmed the growth prospects of Asian native fisheries. As a result, a country can either be a source or a destination for invasive species, and the consequences are felt worldwide. It's important to remember that not all introduction species become invasive. Many species have adapted to the new environment without inflicting ecological harm to native species. Naturalized species are those that have learned to coexist with native species (NOAA).

Since its inception as a study of the geographical distribution of species, biogeography has evolved to include recent trends in invasion biology and the resulting bio-geographical changes. From its beginnings in the study of species distribution in the tropical forests of Brazil and Indonesia, it has expanded to include distribution in urban eco systems and the changing nature of the geography of organisms driven by ecological competence. The topic is not limited to the documentation and description of species in various parts of the world, but also includes the dynamics of range shifts and their ecological and biological consequences. Since Wallace's time, as global warming has pushed species to higher latitudes and altitudes, new research options have emerged, changing the subject into one with cross-disciplinary characteristics. Invasion Biology has developed as a theoretical nexus in biogeography research.

2.2. INVASION BIOLOGY:

Biological invasions are one of today's most pressing environmental issues. They are pervasive, have significant detrimental effects on ecological communities' structure and function (D'Antonio and Vitousek 1992, Mack et al. 2000, Vila et al. 2011), and cost a lot of money (Pimentel et al. 2000, Pimentel et al. 2005). Biological invasions have well-established ecological and economic implications, but the mechanisms that drive species invasions have not been well researched.

Biological invasions are studied by ecologists by looking at the controls at each stage of the invasion process: introduction, establishment, spread, and impact as shown in below figure. Importantly, only a small percentage of introduced species succeed in establishing themselves; furthermore, only a small percentage of these spread and have an impact on local groups (Kot et al., 1996)



Brown tree snake:

"After WWII, the brown tree snake was unintentionally introduced to Guam, most likely as cargo from its home habitat in the South Pacific. Guam, like many other remote islands, is devoid of snakes and other top predators, leaving local species vulnerable to snake invasion". In Guam, the brown tree snake reached unprecedented densities, triggering the extinction of most forest-dwelling bird species and decimating the island's reptile and mammal populations (Chapman et al., 2000).

Balsam woolly adelgid:

"The balsam woolly adelgid was the main invader. In the early twentieth century, this plant-eating bug was brought to America on nursery stock from Europe".

Its salivary secretions are toxic to some trees, and it has killed entire stands of mature Fraser firs in the southern Appalachian Mountains.

The adelgid has radically altered the structure of the forest ecosystem it has entered, even though younger trees have survived.

Although the current rate of species introductions is extraordinary, the process is not new. Long-distance colonisation has always been a part of the earth's biogeographic history, and tectonic activity has often aided it.

Species transfer across biogeographic borders, on the other hand, is now several orders of magnitude faster than it was previously. This is a sort of biological pollution, similar to high levels of a chemical pollutant that is normally present in trace amounts in the environment (Marshall et al., 2006).

P. australis (plant invasion):

"P. australis is one of the most effective invaders of North American wetlands (Saltonstall 2002, Guo et al. 2013)". It has been actively conquering North American interior freshwater and brackish coastal wetlands, resulting in vast monotypic stands. Following this species' invasion, the wetland environment undergoes a series of ecological changes. It displaces native plants (Silliman and Bertness 2004, Minchinton et al. 2006), changes the diversity and composition of associated faunal communities (Angradi et al. 2001), and alters ecosystem processes like nutrient cycling (Bart and Hartman 2002, Windham and Ehrenfeld 2003) and hydrological regimes (Angradi et al. 2001 and Windham and Lathrop 1999).

Invaders cause rivalry, predation, and illness, which are the most usually imagined consequences. For example, Argentine ants are much more aggressive competitors than the native ant fauna they frequently displace. Exotic zebra mussels outgrow native bivalve rivals in North American water systems and filter feed so well that plankton levels plummet. Exotic pathogens are less visible, but they can cause significant damage. The American Chestnut tree is on the verge of extinction due to chestnut blight, a fungal infection mistakenly brought from China (Kot et al., 1996 and Levine et al., 2003).

Changes in ecological processes such as the nutrient cycle, hydrology, and fire regimes are among the most severe impacts of invaders.

Fires devastate woody taxa disproportionately, favouring grass invasion. Invasive coqui frogs, which have some of the highest known numbers of terrestrial amphibians, devour a lot of insects in Puerto Rico. In their faeces, frogs convert nutrients locked up in insect biomass into plant-available compounds, which reduces arthropod numbers. This changes the nitrogen cycle in the forest and boosts plant development (Parker et al., 2006).

The question of whether biological invasions result in the extinction of native species is one of the most obvious, but difficult, questions in the study of biological invasions. Despite the fact that invaders are one of the most serious dangers to native species diversity and population size, invasions have only resulted in the extinction of a small number of species. Invader refuges are frequently found somewhere in the range of native species. It remains to be seen whether native species can thrive in these protected areas. However, the number of invasions has greatly outnumbered the number of extinctions that have resulted in the near term.

3. OBJECTIVES:

Biogeography and Invasion Biology research was conducted. A theoretical study examines how species bio invasion occurs and results in adverse consequences of biodiversity loss. We've focused on several species that have been invaded in this study, including birds, mammals, and plants. Biogeography's history is also discussed.

Author/Year	Descriptions
Pimentel et al. (2005), Meyerson et al. (2019)	Invasive species are a major source of worldwide economic and biodiversity loss, costing the United States alone $100 billion per year.
Williamson & Fitter (1996)	Although there is no mathematical justification for the tens rule, it states that on average, approximately 10% of introduced species become invasive, and about 10% of those become pest (i.e. harmful).
Jeschke & Pyšek (2018)	According to a recent quantitative meta-analysis, the fraction of non-native plants and invertebrates that may transition along the invasion pathway may be significantly greater, with roughly 25% of non-native plants and invertebrates and nearly 50% of non-native vertebrates capable of doing so. Regardless, one of the main goals in the study of biological invasions has been to figure out which species will be successful and where they would thrive.
Byers (2009)	The differences in species performance discovered could provide insight into the processes that allow species to establish and spread once introduced to a new environment. Comparative biogeography also provided a way to put mechanistic theories about why invasive species outperformed native species to the test. The goal of these biogeographical comparisons was to see whether there were any environmental or biotic variations between the native and introduced ranges that could indicate that the invasive species' success was context dependent. A species entering an environment with fewer predators, parasites, or rivals is one example of biological variations that are context-dependent. In the absence of such variations, the species' success appeared to be due to innate taxonomic or physiological traits, implying that the invasion was only hampered by a previous lack of requisite dispersion capacities.
Torchin et al. (2003) and Mitchell & Power (2003)	The researchers analysed parasite prevalence and richness patterns in animals and plants from the native and introduced ranges, and found strong evidence for parasite richness being lower in the introduced region.
Sotka et al. (2018)	Invasive species can adapt quickly in their new surroundings, as evidenced by this study. They showed that native source populations of the red seaweed Agarophyton vermiculophyllum live in colder, more seasonal settings, whereas most invasive populations live in warmer, less seasonal habitats, using a genetically informed climatic niche shift analysis. Invasive populations, as a result of their climatic niche expansion, are expected to have developed a stronger tolerance for high temperatures than native source populations.
Roman & Darling (2007)	Traits may be controlled by genetics, as this last case indicates. As a result, numerous studies compare the genetic diversity of native and introduced populations of a species. Authors rarely link genes to phenotypes; instead, they infer that a species' ability to adapt is harmed by a reduction in genetic diversity. Although genetic bottlenecks are assumed to occur during the introduction process and reduce invading species' genetic potential to adapt to new settings, genetic bottlenecks in invasive species may not be as common as previously thought.

Hierro et al. (2005) and Parker et al. (2013)	Terrestrial ecosystems have traditionally provided evidence for invasive species life-history or abundance variations between introduced and native regions. However, for many marine invasive species, evidence of biogeographic alterations in their introduced versus native range has been progressively rising over the last 15 years or so.
Grosholz & Ruiz (2003)	12 of 19 invertebrate species had larger bodies in their introduced range, according to the study. Numerous intraspecific biogeographic comparative studies provide additional support.

5. RESEARCH METHODOLOGY:

This research paper, titled "Biogeography and Invasion Biology-A Theoretical Study," is based on a review of the literature as well as true studies made available to the public all around the world. We gathered linked relevant material that supports or contradicts the items listed in the research's Introduction Section, and then conducted our analysis based on the findings of the background investigation. Our research, which includes factual findings, has resulted in these study subjects.

- Biogeography description in a nutshell (national and international perspectives).
- Introduction to Biological Invasion in a Nutshell.
- Some species are depicted to show how diversity is rapidly dwindling.
- Biological invasion's future problems and potential.

6. DATA COLLECTION:

As a result, verified legitimate official portals, research/survey/journal references in this field, opinion polls, and review reports formally provided by the related agencies/institutions/functioning bodies/research organisations are used to compile facts, data, and information. It is gathered secondary data. Up until the year 2019, data and information will be collected. The reliability of this data/information is confirmed using the credentials and methodology mentioned in those information sources, and it is extensively checked to ensure that it does not contain any conflicting or misleading facts that could jeopardise social, political, economic, or other platforms.

7. OBSERVATION AND ANALYSIS:

7.1. Australia:

The Hawaiian Islands' alien ant (Iridomyrmex humilis). They have been proven to have a deleterious impact on the endemic arthropod fauna of the area, especially pollinators. The spread of non-indigenous plant species is one of the most serious threats to Australia's biodiversity. Almost every major ecosystem has been significantly affected, and damage is expected to continue as these species expand their range. Thousands of square kilometres of native vegetation are being displaced by exotic trees and plants. Among the more aggressive tree and shrubs are "prickly acacia (Acacia nilotica), rubber vine (Cryptostegia grandiflora), parkinsonia (Parkinsonia aculeate), mesquite (Prosopis spp.), and giant sensitive plant (Mimosa pigra), pond apple (Anona glabra), Ponded pasture grasses such as para grass (Brachiaria mutica) and other" (Aliens; 1995).

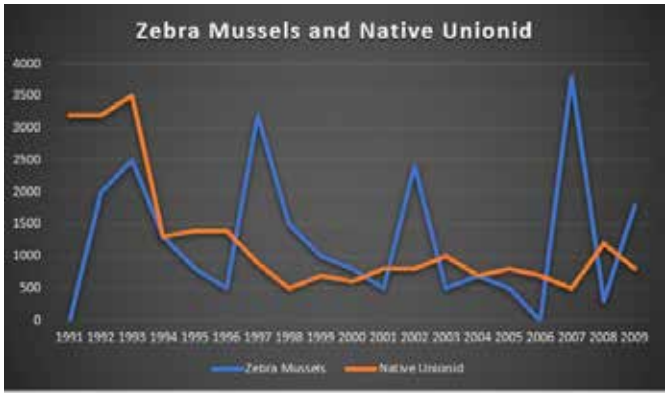
7.2. Europe:

In Europe, there are 11000 alien species. Terrestrial plants account for more than half of them. Invertebrates, both aquatic and terrestrial, make up 30% of species, while vertebrates make up only 5%. According to recent foreign statistics, Europe now has more than five times as many bird species, three times as many mammal species, and twice as many plants as it did just over a decade ago. Numerous species from various continents can be found in Europe, including "Canada goose (Branta canadensis), American bullfrog (Lithobates catesbeianus), Argentine ant (Linepithema humile), Egyptian goose (Alopochen aegyptiacus), Indian strawberry (Duchesnea indica), Chinese mitten crab (Eriocheir sinensis), Japanese oyster (Crassostrea gigas), New Zealand flatworm (Arthurdendyus triangulatus), Japanese knotweed (Fallopia japonica), grey squirrels (Sciurus carolinensis), Mexican tea (Chenopodium ambrosoides), knotgrass (Paspalum paspaloides), Canadian horseweed (Conysa canadensis), Bermuda buttercup (Oxalis pes-caprea), giant hogweed (Heracleum mantegazzianum), American pokeweed (Phytolaca amerikana) and silverleaf nightshade (Solanum eleagnifolium), acacia species (Acacia), rhododendron (Rhododendron pontica), American mink (Mustela vision), Asiatic clam (Corbicula fluminea) and other" (DAISIE; 2009).

7.3. U.S:

In the United States, there are around 50,000 foreign species, and the number is growing. About 42% of the species on endangered or vulnerable species lists are imperilled mostly due to foreign invasive species (Pimentel David et al., 2004). The major threat to biodiversity is around 4000 kinds of exotic invasive plants and 2300 nonindigenous invading animals. There are some invading animal species to be aware of, such as: "goats (Capra hirus), the European black or tree rat (Ratus ratus), Asiatic (Norway or brown) rat (Rattus norvegicus), house mouse (Mus musculus), European rabbit (Oryctolagus cuniculus), domestic cat (Felis cattus) and dog (Canis familiaris) and other" (Layne J.N et al., 1997).

Zebra mussels are one of the most significant biological invasions in North America, having had a significant impact on invasion biology research as well as public perception and policy. Below graph depicts Zebra mussels biological invasion from year 1991 to 2009:



8. CONCLUSION & FINDINGS:

Invasions are more than a one-way street when it comes to biogeographic analysis. Throughout this post, we've emphasised how descriptive analysis can help us learn more about invasive species biology. Invasive species may also provide biogeographic information. Invasive species, after all, provide a unique opportunity to learn about biogeography because you can't study species in similar climatic regions where they don't already exist without invasion. Given the difficulty of operating at continental dimensions, it is somewhat understandable that biogeographic research, particularly experimental ones, are limited, despite the enormous amount of the biological invasion literature. However, as we've shown, the expanding number of research offers intriguing insights and much-needed evidence for theoretical biogeographic analyses of invasive species' success. As researchers close many of the knowledge gaps we've exposed, the evidence for and against these studies should improve over time.

9. FUTURE PROSPECTS:

In an era of fast worldwide change, anticipating species distributions in novel or non-analogue habitats is critical to conservation biogeography (Sala et al., 2000), Diversity and Distributions should be extensively studied in research that develops and tests novel ways of forecasting impacts of global change – climate change, land use change, invasive species including emerging infectious diseases, altered disturbance regimes – on biodiversity. Incorporating diversity information below the species level could be especially useful for identifying genetically and regionally organised populations that differ in their ability to adapt to environmental change (Hamann & Aitken, 2013) or for conquering new areas (Thompson et al., 2011).

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